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CHEMICAL WARFARE AGENTS WITH PARTICULAR REFERENCE TO WATER CONTAMINATION

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CHEMICAL WARFARE AGENTS

with particular reference to

WATER CONTAMINATION

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TABLE I

CLASSIFICATION OF CHEMICAL AGENTS

UPON BASIS OF TOXICITY IN WATER

Group 1	Agents which probably will produce a non-toxic water, though it may be non-potable	Thiodyglycol Incendiary Agents Screening Smokes
Group 2	Agents producing a turbid water which is non-toxic after removal of the turbidity	Adamsite Diphenylchlorarsine Diphenylcyanoarsine
Group 3	Agents present in fairly high concentrations which would produce a non-toxic water	Phosgene
Group 4	Agents likely to cause trouble in a water supply unless extra precautions are taken	S-Mustards N-Mustards Lewisites Nerve Gases Fluoroacetates

TABLE II

CHEMICAL BEHAVIOR OF AGENTS IN WATER

Class	Name	Formula	Solubility mg/l	Hydrolytic Rate	Hydrolytic Products Toxicity	Taste & Odor
Vesicants	S-Mustard	$(ClC_2H_4)_2S$	700	Slow	Non-toxic	+
	N-Mustard	$(ClC_2H_4)_3N$	100 or more	Slow	Toxic	+
	Lewisite	$CHClCH \cdot AsCl_2$	10,000	Rapid	Toxic	+
Lung Injurants	Phosgene	$COCl_2$	Soluble (Hydrolyzes Instantly)	Very Rapid	Non-toxic	-
Sternutators	Adamsite	$(C_6H_4)_2 \cdot NHAsCl$	60	Stable	Toxic	-
Nerve Gases	Diisopropyl fluoro-phosphate	$[(CH_3)_2HCO]_2POF$	High	Slow	Usually Non-toxic	-
Fluoro-acetates	Methyl Flucroacetate	FCH_2COOCH_3	High	Extremely Slow	Usually Non-toxic	-

TABLE III

INTERPRETATION OF SIMPLE TESTS ON WATER CONTAMINATED WITH CHEMICAL WARFARE AGENTS

Test Used	Drinking Water Standard* (p.p.m.)	Change required in criterion to suggest contamination	Limit beyond which water is not potable and dangerous when gas contaminated
Odor	No unpleasant odor	Any unpleasant odor	Any recognizable odor of vesicant or other toxic war gas
Turbidity	10	---	20 p.p.m. or more
pH	---	Decrease 0.3 unit or more	Lowering of 1.0 pH unit below normal average for water
Alkalinity	---	Decrease of 5 p.p.m. or more	If alkalinity is lowered 10 p.p.m. or more or a similar increase in acidity is noted
Chloride	250	An unusual increase of 5 p.p.m.	An unusual increase of 10 p.p.m.
Oxygen Consumed	---	Increase of 1 p.p.m. or more	A value of 5.0 p.p.m. or more
Chlorine Demand	---	Increase of 1 p.p.m. or more	A value of 5 p.p.m. or more
Arsenic	0.05	Increase above 0.05 p.p.m.	A value of 1 to 5 p.p.m.

(*) USPHS Pub. Health Rep., 61, 13, (1948), Reprint No. 2697

TABLE IV

Approximate Concentration of Gas in Tap Water p.p.m.	Mustard (HS)			Lewisite (M-1)		
	pH	Alkalinity p.p.m.	Acidity p.p.m.	pH	Alkalinity p.p.m.	Acidity p.p.m.
0	7.6	38	—	7.8	38	—
10	7.2	34	—	7.3	34	—
50	5.5	7	—	6.2	15	—
100	3.4	—	21	3.5	—	10
500	2.4	—	256	2.8	—	200

TABLE V

Approximate Quantity of Gas Added p.p.m.	Mustard (HS)		Lewisite (M-1)	
	p. p. m. Chloride		p. p. m. Chloride	
	Found	Theoretical	Found	Theoretical
0	10	18	18	18
10	25	22	23	21.4
50	45	40.3	35	35.1
100	67	62.7	49	52.2
500	254	241	168	189

TABLE VI

WATER PLANT OUTPUT FOR VARIOUS URBAN POPULATIONS AND QUANTITIES OF MUSTARD AND LEWISITE REQUIRED TO GIVE A DANGEROUSLY TOXIC WATER

Population Groups	Approximate water plant output gallons per day.	Approximate water plant output gallons per hour.	Approximate capacity of elevated tank or clear water reservoir if used.	Pounds of agent required for dangerous contamination of 1 hour's output.		Pounds of agent required for dangerous contamination of contents of elevated tank or clear water reservoir	
				Mustard (1)	Lewisite (2)	Mustard (1)	Lewisite (2)
1-10 Family well supply	50	5	----	.002	.0011	----	----
100	12,000	500	100,000	.2	.11	41.7	23.1
1,000	120,000	5,000	100,000	2.0	1.16	41.7	23.1
5,000	600,000	25,000	269,000	10.4	5.76	112.1	62.0
10,000	1,200,000	50,000	532,000	20.8	11.55	221.0	122.7
100,000	12,000,000	500,000	22,300,000	208.	115.5	9295.	4220
500,000	60,000,000	2,500,000	58,000,000	1042.	576.	24,510	11,127
1,000,000	120,000,000	5,000,000	189,000,000	2084.	1155.	78,784	35,766

(1) On the basis of a dose of 50 p.p.m. or 416.85 lbs. per million gallons.

(2) On the basis of a dose of 27.7 p.p.m. or 189.24 lbs. per million gallons and results in 10 p.p.m. of As.

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TOXICITY OF NEWER CHEMICAL WARFARE AGENTS

	LD_{50}, mg/kg	
	Subcutaneous	Oral
Nitrogen Mustards	2.6*	20
parathion	---	20(man)
Diisopropyl fluorophosphate	4	---
Tabun	(5 X)	---
Sarin	(20 X)	---
Methyl fluoroacetate	15	---
Capryl fluoroacetate	4	---

*ID_{50}/7

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USE OF CHEMICAL WARFARE AGENTS IN PUPLIC WATER SUPPLIES

(H. P. Kramer)

I. Introduction

Historical

Ancient use

World War I - Super weapon

Development

Use

Casualties produced

Classification Systems

Physiological effects

Persistency

Tactical class

II. Newer Chemical Warfare Agents

N-Mustards

Chemical nature and properties

Some typical members of this family

Physiological effects

Fluoroacetates

Chemical nature and properties

Structure and toxicity

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Fluorophosphates

German research in compounds with organically bound phosphorous

Development of new economic poisons

Chemical nature and properties of fluorophosphates

Classification

III. Water Supplies and Chemical Warfare Agents

Importance of these agents as water poisons

Classification of chemical agents upon basis of toxicity in water

Chemical behavior of agents in water

Hydrolysis of: S-Mustard

Lewisite

N-Mustard

Detection of chemical agents in water

Quantities of agent required to contaminate a water supply

Decontamination procedures

War Gases and Chemicals

Characteristics **Effects** **Protection**

CLASS	NAMES AND SYMBOLS	FORM	ODOR	PHYSIOLOGICAL EFFECT	TACTICAL CLASS	PROTECTION	FIRST AID [After removal from gassed area]	PERSIS
VESICANTS	MUSTARD $S(CH_2CH_2Cl)_2$ Dichlorodiethyl Sulphide	Liquid and Vapor	Garlic, Horseradish, Mustard	Delayed effect. Burns skin or membrane. Inflammation of respiratory tract leading to pneumonia. Eye irritation conjunctivitis.	Hospital case.	Gas mask and full protective clothing.	Undress; remove liquid mustard with protective ointment, bleach paste, or kerosene; bathe; wash eyes and nose with soda solution.	One d week; dry s
VESICANTS	LEWISITE $ClCH{=}CH{-}AsCl_2$ Chlorovinyl-Dichlorarsine	Liquid and Vapor	Geraniums	Burning or irritation of eyes, nasal passages, respiratory tract, skin. Arsenical poison.	Hospital case.	Gas mask and full protective clothing.	Undress; remove liquid Lewisite with hydrogen peroxide, ice in glycerine, or kerosene; bathe; wash eyes and nose with soda. Rest—Doctor.	One d week; dry s
VESICANTS	ETHYLDICHLORARSINE $C_2H_5{-}AsCl_2$	Liquid and Vapor or Gas	Stinging, like pepper in nose	Causes blisters, sores, paralysis of hands, vomiting. Severe on lung exposure.	Hospital case.	Gas mask and full protective clothing.	Undress; remove liquid with hydrogen peroxide, ice in glycerine, or kerosene; bathe; wash eyes and nose with soda. Rest—Doctor.	One
LUNG IRRITANTS	CHLORINE Cl_2	Gas	Highly pungent	Lung irritant.	Hospital case.	Gas mask.	Remove from gassed area. Keep quiet and warm. Coffee as stimulant.	10 m
LUNG IRRITANTS	CHLOROPICRIN $CCl_3{-}NO_2$ Nitrotrichloroform	Gas	Pepper, snow	Causes severe coughing, crying, vomiting.	First-aid treatment and hospital case.	Gas mask.	Wash eyes, keep quiet and warm. Do not use bandages.	Open wounds
LUNG IRRITANTS	DIPHOSGENE $ClCOOC{-}Cl_3$ Trichloromethyl Chloroformate	Gas	Smallage, acrid	Causes coughing. Breathing burn, eyes water, vomit.	Hospital case.	Gas mask.	Keep quiet and warm. Give coffee as a stimulant.	10 m
LUNG IRRITANTS	PHOSGENE $COCl_2$ Carbonyl Chloride	Gas	Musty hay, Green corn	Irritation of lungs, occasional vomiting, tears in eyes, choked feeling. Occasionally symptoms delayed; lung collapse, heart failure.	Hospital case.	Gas mask.	Keep quiet and warm; rest in bed. Coffee as a stimulant. Loosen clothing. No alcohol or cigarettes.	10 m
LACRIMATORS	CHLORACETOPHENONE $C_6H_5CO{\cdot}CH_2Cl$	Gas	Apple blossoms	Makes eyes smart. Shut tightly. Tears flow. Temporary.	First-aid treatment.	Gas mask.	Wash eyes with cold water or boric-acid solution. Do not bandage. Face wind. For skin, sodium sulphite solution.	10 m
LACRIMATORS	BROMOBENZYLCYANIDE $C_6H_5CH{\cdot}BrCN$	Gas	Sour fruit	Eyes smart, shut, tears flow. Effect lasts some time. Headache.	First-aid treatment.	Gas mask.	Wash eyes with boric acid. Do not bandage.	Temp
STERNUTATORS	ADAMSITE $(C_6H_4)_2{-}NHAsCl$ Diphenylaminechlorarsine	Gas	Coal smoke	Causes sneezing, sick depressed feeling, headache.	First-aid treatment.	Gas mask.	Keep quiet and warm. Loosen clothing. Restore. Spray nose with oxygenated gas, or acid bleaching powder. Aspirin for headache.	10 m
STERNUTATORS	DIPHENYLCHLORARSINE $(C_6H_5)_2{-}AsCl$	Smoke	Shoe polish	Causes sick feeling and headache.	First-aid treatment.	Gas mask.	Remove to pure air, keep quiet. Acid chlorine from bleaching-powder bottle.	Ter 10 m
SMOKES	HC MIXTURE $Zn + C_2Cl_6$	Smoke	Sharp-acrid	Harmless.	Smoke.	None needed.	Produces no effect requiring treatment.	Whe
SMOKES	SULPHUR TRIOXIDE $SO_3 + SO_3HCl$ In Chlorosulfonic Acid	Smoke	Burning matches	Causes pricking of skin, flow of tears.	Smoke.	Gas mask.	Wash with soda solution.	
SMOKES	TITANIUMTETRACHLORIDE† $TiCl_4$	Smoke	Acrid	Harmless.	Smoke.	———	Produces no effect requiring treatment.	10 m
INCENDIARIES	WHITE PHOSPHORUS P	Smoke	Burning matches	Burning pieces adhere to skin, clothing.	Incendiary smoke. First-aid treatment.	———	Pack in cloths wet with copper sulphate (blue vitriol) or water or immerse in water. Pick or squeeze out particles. Treat for burn.	10 m
INCENDIARIES	THERMIT $8Al + 3Fe_3O_4$	Incendiary	None	5,000-degree heat ignites materials.	Incendiary.	———	Treat for severe burn.	5 m

Data by Lieut. Col. Walter P. Burn, of the Chemical Warfare Service

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War Gases and Chemicals

Characteristics **Effects** **Protection**

B

PHYSIOLOGICAL EFFECT	TACTICAL CLASS	PROTECTION	FIRST AID (After removal from gassed area)	PERSISTENCE	FIELD NEUTRALIZATION	GENERAL INSTRUCTIONS
Delayed effect. Burns skin or membrane. Inflammation of respiratory tract leading to pneumonia. Eye irritation conjunctivitis.	Hospital case.	Gas mask and full protective clothing.	Undress; remove liquid smeared with protective ointment, bleach paste, or kerosene; bathe; wash eyes and nose with soda solution.	One day to one week; longer if dry or cold.	Cover with undiluted lime and earth; 5% solution of Na_2SO_3.	The importance of proper first aid for gas victims cannot be overemphasized. The following are general rules which apply in all cases.
Burning or irritation of eyes, nasal passages, respiratory tract, skin. Acts on blood.	Hospital case.	Gas mask and full protective clothing.	Undress; remove liquid Lewisite with hydrogen peroxide, lye in glycerine, or kerosene; bathe; wash eyes and nose with soda. Rest—Doctor.	One day to one week; longer if dry or cold.	Wash down with water. Cover with earth. Alcohol. NaOH spray.	
Causes blisters, sores, paralysis of hands, vomiting. Severe on long exposure.	Hospital case.	Gas mask and full protective clothing.	Undress; remove liquid [illegible] hydrogen peroxide, lye in glycerine, or kerosene; bathe; wash eyes and nose with soda. Rest—Doctor.	One hour.	Cover with earth, caustic.	
Lung irritant.	Hospital case.	Gas mask.	Remove from gassed area. Keep quiet and warm. Coffee as stimulant.	10 minutes.	Alkaline solution.	A. Act promptly and quietly; be calm.
Causes severe coughing, crying, vomiting.	Fire-aid treatment and hospital case.	Gas mask.	Wash eyes, keep quiet and warm. Do not use bandages.	Open 6 hours; wounds 12 hours.	$Na_2S_2O_3$ — Sodium sulphite in alcohol solution.	B. Put a gas mask on the patient if gas is still present on, if he has a mask on, check to see that he is properly adjusted. If a mask is not available, wet a handkerchief or other cloth and have him breathe through it.
Causes coughing. Breathing hurts, eyes water, smart.	Hospital case.	Gas mask.	Keep quiet and warm. Give coffee as a stimulant.	30 minutes.	Alkali.	
Irritation of lungs, occasional vomiting, tears in eyes, dazed feeling. Occasionally symptoms delayed; heart, collapse, heart failure.	Hospital case.	Gas mask.	Keep quiet and warm; rest in bed. Coffee as a stimulant. Loosen clothing. No alcohol or cigarettes.	10 to 30 minutes.	Alkali.	C. Keep the patient at absolute rest; loosen clothing to facilitate breathing.
Makes eyes smart. Shut tightly. Tears flow. Temporary.	First-aid treatment.	Gas mask.	Wash eyes with cold water or boric acid solution. Do not bandage. Face wind. For skin, sodium sulphite solution.	10 minutes.	Strong, hot solution of sodium carbonate.	D. Remove the patient to a gas-free place as soon as possible.
Eyes smart, shut, tears flow. Effect lasts some time. Headache.	First-aid treatment.	Gas mask.	Wash eyes with boric acid. Do not bandage.	Several days (weeks in winter).	Alcoholic sodium hydroxide spray.	E. Summon medical aid promptly; if possible, send the victim to a hospital.
Causes sneezing, sick depressed feeling, headache.	First-aid treatment.	Gas mask.	Keep quiet and warm. Loosen clothing. Restmore. Spray nose with ammoniphen or mild bleaching powder. Aspirin for headache.	10 minutes.	Bleaching powder solution.	F. Do not permit the patient to smoke, as this causes coughing and hastens excretion.
Causes sick feeling and headache.	First-aid treatment.	Gas mask.	Remove to pure air, keep quiet, half chlorine from bleaching-powder bottle.	Summer 10 minutes.	Bleaching powder solution.	
Harmless.	Smoke.	None needed.	Produces no effect requiring treatment.	While burning.	None needed.	
Causes prickling of skin, flow of tears.	Smoke.	Gas mask.	Wash with soda solution.	5 to 10 minutes.	Alkaline solution.	
Harmless.	Smoke.	————	Produces no effect requiring treatment.	10 minutes.	None needed.	
Burning pieces adhere to skin, clothing.	Incendiary smoke. First-aid treatment.	————	Pick or climb wet with copper sulphate (blue vitriol) or water or ammonia in water. Pick or squeeze out particles. Treat for burn.	10 minutes.	Burns out.	
5,000-degree heat ignites materials.	Incendiary.	————	Treat for severe burn.	5 minutes.	Quickly cover with earth or sand.	

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